1 INTRODUCTION

1.1 Background
In 2088, the world expected to run out of fossil fuels. Fossil fuels are known as hydrocarbons, primarily coal, oil, and natural gas formed from the remains of dead plants and animals. Typically, millions of years are needed to get the fossil fuels. Meanwhile, currently over 11 billion tonnes of oil in fossil fuels was consumed every year and crude oil are vanishing at rate of 4 billion tonnes per year, with this rate of consumption, this oil deposits will be gone by the year 2052. Although natural gas will be reserved to fill the energy gap left by oil, it will only sustained until the year 2060 and with the energy reserved from coal, it will be enough until year of 2088 (Gore, 2014).

Currently, researchers try to find another alternative energy sources to reduce dependence on fossil fuels, and also to fill the gap left through depletion of oil, gas and coal after 2088 and onwards. Last two decades, researchers found that the biomass can be used as source of renewable energy. Biomass is 3rd largest primary energy source after coal and oil (Linghong et al., 2010). The reason why biomass as a renewable source of energy is because, the energy is released in the form of heat during the combustion and biomass is a renewable energy source of carbon which is can be converted into convenient solid, liquid and gaseous fuels through different conversion process (Ahmed et al., 2011).

Energy conversion from biomass can be done by using different process which are thermochemical (e.g. combustion, and gasification), biological (e.g. anaerobic digestion and fermentation), and chemical process (e.g. esterification). However, raw biomass cannot be converted directly because, it have several problems due to its characteristics, and pretreatment of biomass needed. There are several method for a pretreatment of biomass which are pyrolysis, torrefaction (mild pyrolysis), and microbioal pretreatment. From this three methods, torrefaction is the most suitable, and it is strongly depended on thermal decomposition behavior and lignocellulosic component (Suzana et al., 2011).
1.2 Motivation

Biomass is a 3rd largest primary energy source after coal and oil. Percentage of energy provided from oil is 40%, from coal is about 28%, from biomass is about 20%, and from natural gas which is 12% (Energy resources, 2014). Malaysia is one of the countries with the largest palm oil producer in the world, which is more than 7 million tonnes of empty fruit bunch (EFB), 4.5 million tonnes of palm mesocarp fiber (PMF), and 1.9 million tonnes of palm kernel shell (PKS) are generated as solid wastes (biomass) with increasing of 5% annually (Yang et al., 2004). Total production of palm oil in the end of 2014 is predicted to be more than 19.55 million tonne, and every 20,000 tonnes of fruit fresh bunch (FFB) were collected, about 4,600 tonnes EFB are produced. Increasing in palm oil production, cause the solid wastes increase, in Malaysia, there are about 200 palm oil mills in total operations.

Meanwhile forestry residues is a biomass material that remained in forest and has been harvested for timber, including logging residues, excess small pole trees, natural attrition, extracting stem-wood for pulp and a rough or rotten dead wood (EPA, 2014). Due to the huge amount of biomass generated yearly, Malaysia has a potential to utilize the biomass efficiently and effectively as an alternative energy source to replace fossil fuels (Shuit et al., 2009; Sumathi et al., 2008)

1.3 Problem Statement

Raw biomass has low energy density compared to fossil fuels, so large amount of biomass are needed. In addition, it is hard to grind the biomass and it can be very costly. Raw biomass also have a hygroscopic behaviour which is it cannot be stored for long time. Because of those problems, pretreatment of biomass is needed, and the method that suitable and compatible with characteristic of biomass is torrefaction.

Biomass torrefaction has been recognized as a technically feasible method for converting raw biomass into high-energy-density, hydrophobic, compactable, grindable, and lower oxygen-to-carbon (O/C) ratio solid (Tumuluru et al., 2010). In torrefaction process, it was strongly depended on the thermal decomposition behavior and lignocellulosic constituents. In order to identify the decomposition regions of palm oil and evaluate kinetic parameters, and mass changes, thermogravimetric analysis (TGA) can be used. In this work, PKS, EFB, mersawa sawdust and durian were used.
1.4 Objective
The objective of this research is to study the thermal decomposition and characterization of palm oil waste and forestry residues during torrefaction process.

1.5 Scope of this research
The scope of this study will focus on decomposition profile/region within hemicellulose, cellulose, and lignin of the palm oil waste (PKS, and EFB), and forestry residue (wood waste, and sawdust). Sample mass must in the range ±5mg, the temperature must not over than 600 °C, and heating rate were used are 10 °C and 20 °C/min. Palm kernel shell (PKS) is a by-product from production of kernel oil. Palm kernel nut contain kernel oil was cracked down to kernel and kernel shell. Meanwhile fresh palm oil fruit bunch (FFB) after went through steam heating is put under threshing process, which separate palm fruit from its bunch, it become EFB (empty fruit bunch). Wood wastes are a by-product from wood-processing industries, such as sawdust, shavings, chips, and barks. To use this biomass, it was grinded and sieved to particle size of 500-630µm. To study thermal decomposition and characterization of biomass, this experiment was performed under nonisothermal conditions in standard TGA (TGA Q500, from TA instrument).

1.6 Organisation of this thesis
Chapter 2 provides a description about the biomass. A general description, characteristics of the biomass, and type of biomass used will be explained. In this chapter also provides a brief explanation of the torrefaction and thermal decomposition. Then, thermogravimetric analysis of the biomass will be discussed. A summary of the previous experimental work on thermal decomposition of biomass is also presented.

Chapter 3 gives a review of the biomass used for thermogravimetric analysis and provide the procedure to prepare the biomass samples and to run the experiment by using thermogravimetric analysis (TGA). Flow diagram will be included.

Chapter 4 will discuss about the result of this research. Discussion on the result will cover for all the scope of this study, which is the weight loss, decomposition region between the lignocellulosic components, and characteristic of biomass.